LATENT LIFE, OR, APPARENT DEATH

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TO the ordinary person nothing seems easier than to be able to distinguish between life and death, or to be less abstract, between a living animal and a dead one. A child can tell a dead tree in the woods when it sees one. A person naturally thinks of the entire organism as alive, the signs of its life being that it is warm, that it breathes, that its heart beats and that it is aware of its surroundings, all of which is in sharp contrast with the cold, still, unconscious corpse in which the beating of the heart has ceased for ever.

If asked to say whether an animal lying in the road was alive or dead, we should at once try to arouse it, stimulate it as it is technically called, and if, on its receiving the stimulus—a shout, a pin-prick, a touch with the boot—the animal jumped up or turned over, you would at once say it was alive; if it failed to so so, you would assume it was dead. In physiological language, an animal on being stimulated if alive will respond in some way or other, if dead it will not. Exactly the same reasoning applies to the isolated tissues, heart, muscle, etc., of the body; if they are alive they respond to stimulation, if dead they do not.

Response or reaction to the environment is then the great criterion of life; this property of being able to respond to a stimulus is called affectability or irritability. A dead organism having no affectability, fails to respond to stimulation; it is dead to the world. Response to stimulus is the chief test of livingness whether of individual, organ, tissue or cell.

Now we can state quite precisely the differences between a living animal and a dead one, for at present we are leaving plants out of account.

A living animal organism is characterized by the following capabilities or powers:

(1). It can feed, that is assimilate to itself material (food) chemically often quite unlike the composition of its own tissues, for cannibalism is not exactly a common custom. This digestion and incorporation involves excretion, or the getting rid of material

useless or injurious to the organism. The one word "metabolism" covers all the changes wrought on matter by a living being.

(2). It can transform the potential energy of food into the kinetic energy of heat (animal heat), movement, nerve-energy and electric current. A living organism under this aspect is an energy-transforming machine.

(3). It is able to resist infection and, within limits, all agencies tending to compromise its integrity. It can manufacture anti-bodies, as they are called; they are biochemical responses to biochemical insults.

(4). The living body has a life history; it has birth, youth, prime, senescence. In other words, it goes through an orderly sequence of irreversible phases. Every living thing springs from an egg or ovum, which, being duly fertilized, enters on a course of evolution or progressive unfolding of its tissues from the simple to the complex, from the few to the many, from the immature to the mature. The living being is never stationary; it has time relations. It is interesting to note that amid this constant change of material, the personality or identity of the organism is maintained.

(5). Finally, it can reproduce itself: clearly all organisms that are to survive must be capable of reproducing their like. Except in the lowest forms, where buds can be cast off and thereafter attain to the likeness of the parent (asexual method), the method is the sexual, which requires the congress of two physiologically different individuals, the male and female parents from whom proceeds the new organism.

None of these things can a dead organism do; it can not feed, nor excrete nor produce heat; it passes through no sequence of events, it can not reproduce itself, and finally it putrefies. Death, then, is the permanent impossibility of exhibiting the characteristics of vitality; it is an irreversible state. In the author's terminology, death is a state of infinite physiological inertia, the biological antipodes of affectability.

Livingness is exhibited not only by entire organisms but by their constituent tissues and cells. For tissues and cells can feed, excrete, produce heat and electric current, give rise to anti-bodies, and, finally, produce new elements. The reason for the life of the entire individual is that each of its ultimate constituents is alive.

In judging of the livingness of isolated organs, tissues and cells we must have some convenient method capable of being followed out in the laboratory. The signs of life in the laboratory are, for instance, in the case of muscle—it absorbs oxygen, it gives out carbon dioxide, it produces heat, it twitches or contracts, and finally it can evolve an electric current.

Of all these signs of life, the one mentioned last is by far the most delicate, for tissues which have long since ceased to exchange gases with the atmosphere and even to produce detectable heat, can still give an electric current on being adequately stimulated. The isolated heart of the frog or tortoise, for long after its gaseous exchanges and heat-production are imperceptible, can yield distinct electric currents to that sensitive instrument, the galvanometer. Even after the heart has ceased to beat, as far as the unaided eye is concerned, it can still spontaneously evince electric disturbance; tissues other than the heart of course need first a stimulus. The evolution of electric current is, then, the most delicate sign of life, and it is also the last sign.

But it is also the first sign of life, for Professor A. D. Waller, the English physiologist, has shown that the hen's egg will give an electric current just as soon as the almost invisible speck representing the future chick is constituted on the surface of the yolk. Such widely different things as brain, liver, heart, muscle, eye, seeds, green leaves, fruits and sea-weed will, on being stimulated, produce an electric current. These currents are of course of very feeble voltage; only in electric eels and other fishes are they so powerful as to cause the death of other animals. The electric current, since it is producible as soon as a being can be said to be alive at all, and since it can be recorded long after every other sign of life is gone, has been picturesquely called the alpha and omega of animate existence.

Now it is clear that there must be *degrees* of livingness in tissues, for, whereas some like liver and heart are intensely alive, others such as the upper layers of the skin have little vitality and yet others—enamel of teeth and horn of nail and hair—are absolutely dead. Thus when Horace said "non omnis moriar" he was not even altogether alive.

It is similar with entire organisms; we can construct a scale of all degrees of livingness from the great physical and mental vitality of a Helmholtz, a Gladstone or a Kelvin at one end, down to the somnolent stupidity of the country yokel at the other. Furthermore, vitality undergoes diurnal variations, being at its maximum at about ten o'clock in the forenoon and at its minimum between 3 and 4 o'clock a. m., a time when it is well known those who are moribund usually die. Napoleon, whose saying that an army marched on its stomach is based on sound physiology, used to say that what concerned him was the state of a man's courage at 4 a. m.

Compare the degree of vitality enjoyed by a eupeptic young man just returned from a holiday with the depression of the hopeless sufferer from melancholia. In melancholia all the tissues are

demonstrably less alive, less oxygen is absorbed, less carbon dioxide excreted and less heat evolved.

Dr. Waller has shown that a green apple gives on stimulation a more intense electric response than a ripe one, for the excellent reason that it is younger, less mature. But that it not all: if the green apple and the ripe one be very nearly killed by having had sent through them a very violent electric stimulus (shock), both apples for a time will be unable to show electric current but the young apple will revive sooner than the the older one. The analogy with human beings is surprisingly close.

Medical thought at the present time is greatly interested in that other sign of vitality, namely, resistance to infection, the power of making anti-bodies of which the class called anti-toxins is the best known.

New vegetables and animals can enter into a certain state in which, although they are not showing any of the ordinary signs of life, they are nevertheless not dead: this state is called latent life. The only sign of livingness exhibited in latent life is the electric current of Waller: in all other respects the organisms or tissues may be regarded as dead. They are taking in no oxygen, giving out no carbon dioxide, evolving no heat and are performing no movements, so that the condition is also called apparent death. A dried seed is a good example of this condition; it seems dead, but the ordinary person can ascertain whether or not it is dead by planting it in the ground and waiting until it has or has not produced a plant. If it produces a plant it was alive, but we have lost our seed, although we have gained a plant. Similarly, to know whether an egg is alive(impregnated) or not, "wait and see" if it hatches; if it does it was alive, but again we have lost our egg if we have gained a chick. Waller's method with seeds or an egg is to send a strong (electric) shock through it; if it produces an electric response it is alive. Not only has Waller used the electric response as a sign of life, he has also made it a quantitative measure of the degree of vitality. He selected a number of seeds of Phaseolus from one to five years old and tested one of each age for the production of electric current. The responses in fractions of a volt were for the five years respectively—0.0170; 0.0052; 0.0043; 0.0036; and 0.0014—a very remarkable demonstration of the statistical aspect of livingness. The older the seed the less the response; it is what one would have supposed, but it could not be taken for granted.

These seeds were dry, they were to all intents and purposes dead; they were lying in a pill-box doing nothing vital, but they were not dead, they were in latent life; they could germinate and

they could produce electric current. Drying is an excellent method for sending many living things into la vie latente. It used to be asserted that wheat found in mummy cases could germinate. Mariette, the Egyptologist, definitely denies that this wheat can do so; placed in water it becomes a clayey pulp. It is true, however, that seeds of the gorse have germinated after being 30 years in latent life; seeds, after 87 years in a herbarium have sprouted, and seeds kept for 200 years have actually produced plants. Becquerel, the French naturalist, submitted the seeds of wheat, mustard and lucerne to the following drastic treatment—having perforated the seed-coats, he dried the seeds in a vacuum at 40° C. and sealed up the seeds in a tube almost exhausted of air for one year, submitted them to the temperature of liquid air (minus 198° C.) for three weeks and of liquid hydrogen (minus 250° C.) for three days and then placed them on moist cotton wool, when they germinated! Some fairy tales are not so interesting as this.

But it seems that even animal organisms can enter into latent life. Ever since 1719 we have known this, for the Dutch naturalist, Leeuwenhoek, found minute animals called Rotifers dried up in mud apparently dead but able to live again when moistened with water.

This rising as it were from the dead is called Anabiosis. Besides the Rotifera, or wheel-animalcules, other minute animals the Tardigrada, or bear animalcules, the Anguillulidæ, or paste-eels, and some kinds of thread worms are all known to be able to survive extreme degrees of desiccation for as long as twelve years. These animals are in a state very closely resembling death, but it is not death for it can be recovered from. Death is the permanent impossibility of living again; it is an irreversible state which latent life is not. From death Science knows no recall, no resurrection, but from latent life it does. From it an organism can either go back to full life or on to death. Latent life rather than sleep is the image of death.

Obviously, only simple or lowly animals can live after being dried up; and yet the wheel-animalcules are not so extremely simple seeing that they have a nervous system.

A much more widely applicable method of sending organisms into latent life is that of cooling them. By abstracting their heat, a large number of very different sorts of plants and animals can be so devitalized as to become apparently dead; that they are not dead is known only from the fact that on being thawed they can evince the usual signs of life.

The bacteria, the simplest of all plants, show extraordinary resistance to refrigeration, for it has been proved that they can

be frozen down to the temperature of liquid air and yet retain their vitality. The late Professor MacFadyen chilled certain disease-producing organisms down to the temperature of liquid air and made them so brittle that they could be powdered up in a mortar, but after all this severe treatment it was found that on being thawed, they had retained all their disease-producing properties. The bacteria of putrefaction have been frozen at the temperature of solid alcohol and have yet on thawing retained their full capacity to cause putrefaction. These frozen bacteria were evidently not dead but only in latent life. The fact that the "germs" of decomposition of meat can be sent into latent life by being frozen is taken advantage of in the commercial process of cold storage. The beef is dead and, as we all know, liable to putrefy unless it is frozen. Were there no germs of putrefaction on the meat it would not putrefy; but it does not "go bad" on its journey from the Antipodes because the germs of putrefaction on it are by the refrigeration sent into latent life. That they are merely in suspended animation and not dead is proved by the familiar fact that as soon as the meat is thawed out, it will "go bad" with great rapidity which means that the bacteria on it and in it have returned to their active vital condition of fermenting or decomposing the meat.

Recent research on the preservation of fruit in refrigerators has shown that the spores of the Black Spot fungus can be kept for six months at minus five degrees centigrade and yet germinate at ordinary temperatures. It is a curious fungus, for its optimum temperature is as low as zero centigrade. The whole problem of the storage of fruit is being studied in the light of recent work in Biology. Fruits—apples and pears—pulled off the tree and kept for some time are still alive; in fact they are still breathing, that is taking in oxygen and giving out carbon dioxide; they are not dead, they are not even in latent life. They are not dead because, for one thing, they are not putrefying, and in fact their tissues and ferments are still too active to permit of them being described as in latent life. They are, as everyone knows, ripening, and this consists in their ferments forming sugar out of un-sweet materials. By being chilled, however, fruits can be brought into latent life which is evidently the condition to have them in if storage for a long time is desired.

Apples keep best at one degree centigrade; freezing the fruit destroys it because it breaks up the structure of the living cells and kills them and so prepares them for active decomposition. Of course, to freeze a solid mass like an apple requires a temperature lower than the freezing point of water (0° C.). Apples are found

to live best, that is "keep" best in an atmosphere containing more oxygen and much more carbon dioxide than does the ordinary air.

Coming now to the animal kingdom, we find that by the application of cold many organisms can be sent into latent life. Sir Ernest Shackleton has reported that in the South Polar seas there are certain lowly marine organisms frozen motionless in the ice for ten months in the year, but able to swim about actively for the other two. They pass alternately from life to latent life, from apparent death to life; they have a yearly anabiosis. As one might expect, the cold-blooded animals survive degrees of refrigeration which would kill the warm-blooded. Physiologists know that snails, water-beetles, insects, frogs and fish can withstand temperatures so low that warm-blooded animals would be killed outright.

Sir John Franklin in his Polar Expedition of 1820 reported on carp fish frozen so hard that the intestines of some of them could be taken out en bloc, and yet that others of the same batch of fish revived and moved actively when thawed before a fire. Fishes frozen in a block of ice at minus 15° C. have been known to survive although the bodies of some of their companions were so hard they could be powdered up along with the ice. A fish has been frozen in a block of ice, then sawn in half along with the ice and each half has, on being melted, performed active movements.

The louse (Pediculus) has been known to be alive after no fewer than seven days submersion in freezing water. The frog is an animal that can withstand being frozen without being killed. It is possible to exhibit at the beginning of a lecture on physiology a frog frozen so stiff that it can be held out horizontally by the toes like a piece of board and yet, on allowing the frog to thaw, to show that it can skip about before the end of the hour like any other healthy animal.

On the approach of winter frogs descend into the mud at the bottom of the pond and there rest in latent life until next spring; this is their form of hibernation. In all probability they are not frozen stiff, but their life processes must be at an exceedingly low ebb. Snakes behave in a similar manner.

The French scientist Pictet has stated that frogs can endure a temperature of minus 28° C. This seemed to the writer so very low a temperature for frogs to live through that he made a number of experiments on the subject to gain further information.

He found that frogs could be frozen stiff as regards their skin and muscles and yet remain alive inasmuch as their hearts were still beating although probably not carrying on an efficient circulation of blood. It was found that if ice formed around the internal organs and especially around the heart, they could not sur-

vive. It was shown that, in the case of a frog whose mouth temperature had been minus 7.5° C. for three hours, and whose heart had stopped beating, that the muscles of the eyes and of the tongue would still respond by twitching when stimulated by powerful electric shocks. It was found that the duration of chilling had an important effect, a frog whose internal temperature was minus 10° C. was alive at the end of the first hour but not at the end of the second. Temperatures lower than minus 10° C., if the frogs survived them, could have been endured only for comparatively short periods.

When we come to the warm-blooded animals, we find that, as might be expected, they cannot withstand anything like the extreme degrees of drying and chilling which the more lowly and hardy animals are able to endure. Nevertheless tissue changes can become so depressed in some of the warm-blooded animals that a state of virtually latent life can be entered upon. Such a condition is seen in the hibernation or winter sleep of bears, tortoises, hedge-hogs, dormice and marmosets. On the approach of winter these animals, having already laid on a large store of fat, retire into some place of shelter, and, ceasing to breathe, go into a deep sleep until the spring. The amount of oxygen they consume is the irreducible minimum, the heat they evolve is very small; they live on their own body-fat and other tissues, for of course they eat no food at all. When they emerge next year they are extremely thin. We learn from these cases of hibernation that even after breathing ceases, the animal may yet live; but it may surprise some readers to learn that even after the heart has ceased beating the organism does not necessarily die all at once. The fact is, many of the tissues of the body live for a long time after the body as a whole is dead. In more technical language this is local life after somatic death. Thus some muscles live for hours, and the skin and hair-roots live for days after general or somatic death. It is well known that if the face be shaved *immediately* after death, that the hairs will have grown to a perceptible extent within the next day or two. In regard to the human being, we pronounce the person dead when breathing has ceased and the pulse is no longer perceptible. The breathing may be so slight that only by the moisture of the breath condensing on a mirror can it be known to be going on. Shakespeare alludes to this in King Lear:

> I know when one is dead and when one lives;
> She's dead as earth—lend me a looking glass.
> If that her breath will moist or stain the stone,
> Why then she lives. (Lear, Act V, sc. 2).

Though the pulse at the wrist be no longer felt, yet the heart

may be alive, fluttering rather than beating in such a condition that if we could get at it and massage it, it would revive to some extent for a time at least. This possibility is now made use of by the surgeon whose patient's heart may stop during an abdominal operation. Without loss of time he inserts his hand into the wound and strikes the heart a few gentle blows through the diaphragm with the result that the heart sometimes recommences beating.

It may be now asked, can a human being enter into the state of latent life? The answer is "Yes;" but in so replying, we must recollect the kind of suspended animation which is compatible with the delicate protoplasmic structure and the complicated chemical behavior of human tissues. No mammal, no human being can be dried up or frozen stiff like some of the lowlier creatures and yet live. What we may admit is that life in man can be retained when all the vital processes have sunk to a minimum.

What is known as trance or narcolepsy is the form which latent life takes in the human being. Every now and again we hear of cases of persons, usually young women, going into profound and prolonged sleep from which they do not awake for weeks or months. During that time they take no food, they scarcely breathe, their heart's action is at a minimum. This is of course quite different from the hypnotic or mesmeric trance. Some people fear this state of trance very much; they are in dread of falling into it and being buried before they are really dead. Hence they insert explicit injunctions in their will that their physician is to open a vein or in some other way assure himself that they are dead before burial is permitted.

It is doubtless true that certain persons have been buried alive in the sense that while the heart's action was still at a minimum, they have been placed in a coffin. Stories of persons "laid out" for the undertaker, and reviving on his arrival are not unknown. Some persons have revived on the bier; but the number of persons buried while the body as a whole lived is in reality very small. Moribund persons have been buried at times of great confusion during plagues and epidemics.

Possibly the most famous case of narcolepsy is that of Colonel Townsend of Dublin which has been described by the well-known Dr. Cheyne:

> He could die or expire when he pleased, and yet . . . . by an effort he could come to life again. He composed himself on his back and lay in a still posture for some time . . . . I found his pulse sink gradually, till at last I could not feel any by the most exact and nice touch.
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> Dr. Baynard could not feel the least motion in the breast nor Dr. Skrine perceive the least soil on the bright mirror he held to his mouth . . . . could not discover the least symptom of life in him. We began to conclude he had

carried the experiment too far, and at last we were satisfied he was actually dead . . . . By nine in the morning . . . . as we were going away we observed some motion about the body, and upon examination found his pulse and the motion of his heart gradually returning; he began to breathe heavily and speak softly.

Still more extraordinary are the narratives of the Fakirs of India who are said to allow themselves to be built up in sealed tombs for weeks without food and to be alive at the end of that time. Reports of these cases of human suspended animation are now too numerous and too well authenticated by European eye-witnesses of unimpeachable integrity to be set aside as either in themselves untrue or as due to collective hallucination.

Many people if asked to give an example of suspended animation would refer to the case of some one apparently dead through drowning. Strictly speaking a person rescued from drowning may be moribund, but not quite dead; there is, in physiological language, enough local tissue life present to ensure the living of the entire organism provided oxygen be got into the blood and so to the tissues before they utterly perish. Therefore, still speaking strictly, a drowned person is *not* in latent life, not in a condition which can be kept up indefinitely and which will pass into full life in due time. On the contrary, a drowned person is dying; but most fortunately, the several tissues do not die the moment the individual as a whole dies but can survive long enough to be revivable if only enough oxygen can reach them sufficiently soon. Of course, it all depends on the heart and nervous system; if the heart is dead the individual cannot live again; if the heart, though moribund, is capable of absorbing oxygen and of beating again, the individual will live provided also his central nervous system and particularly the center for breathing is still alive. In the actual practice of "first aid," it is well to assume that the person is alive and to persevere with artificial respiration while keeping the body warm for as long a time as two or three hours before pronouncing life extinct.

The tales of frogs being found alive in the midst of blocks of marble just broken open in the quarry have been the subject of much controversy but they are not now credited.

The latent life of isolated tissues is a remarkable phenomenon. Alexis Carrel of the Rockefeller Institute of Medical Research has actually been successful in causing tissues isolated from chick embryos to grow in glass vessels in a drop of blood-plasma for as long a time as two or three years at ordinary temperatures. When, however this "culture" was placed in a refrigerator all growth was stopped, and as long as it was chilled, it exhibited no growth, the

isolated tissues having gone into latent life. Fragments of heart muscle can similarly be kept in vitro for two or three months; these beat spontaneously during all that period but ceased beating when sufficiently chilled.

In some few cases latent life seems to be capable of being entered upon after drastic treatment with certain chemicals. The insect, the louse, is a case in point. A recent writer from Russia thus describes its powers of resistance: "The louse is one of the hardiest and most prolific pests: the majority of disinfectants and insecticides he scorns; he can survive having drops of pure alcohol or chloroform dropped on him."

The state of latent life may be regarded as a condition of high resistance towards those conditions which make for death. Abstraction of water and of heat are both of them conditions tending towards death; they involve speedy death in many organisms. But such animals or plants as can reduce their metabolism (respiration and heat-production) to the irreducible minimum may escape death in the half-way house of latent life. It is apparent death, not real death which is a condition that can *not* be recovered from. In the author's terminology, the property of affectability has fallen to a minimum, that of physiological inertia has risen towards a maximum, the absolute maximum being reached in death itself.

All poisons tend to kill protoplasm, to immobilize it; death is the complete immobilization of living molecules; whereas latent life is a degree or stage towards this end. Any agencies like desiccation or refrigeration, or reagents like alcohol or chloroform which diminish molecular mobility, tend to render life latent and thereafter to extinguish it. Upon this partial immobilization depends the efficacy of a large number of our drugs and the action of many poisons. To abolish consciousness we administer chloroform, a substance which, by uniting for a time with certain of the chemically active radicles constituting protoplasm, immobilizes more or less completely the whole molecular complex. The immobilization of the molecules of the cells of the brain has as its psychical correlative the disappearance of consciousness. The anæsthetic really tends to immobilize the brain cells, the cells of the breathing center and the heart cells; what the surgeon wants is cerebral immobilization with its counterpart unconsciousness to pain without heart paralysis which would mean death.

The organism in latent life is not dead for it is capable of manifesting once more all the vital attributes which no dead thing can do. It is however very far from being fully alive, for it may be manifesting none of the attributes of livingness save the possibility of developing a feeble electric current which can be detected

only by a delicate apparatus accessible to biological experts. It is not dead however much it looks it.

In living matter, the molecular whirl is at its intensest; in latent life the molecular whirl is for a time arrested; in death the molecular whirl has been stopped for ever. In life the dancers are in the mazes of an elaborate figure; in latent life each individual is standing stock still; in death every dancer has fallen over. In latent life the weights of the protoplasmic clock have been seized by a mysterious hand; in death they have descended to their full extent and can not be wound up again, for the cord is broken. In latent life there is only a stoppage, in death the end has been reached. In life "the sands of time" are running out rapidly; in latent life the stream has stopped; in death the sand is all in the lower globe.

In a sense very different from what the author of the lines meant it, yet in a sense profoundly true:

> 'Tis not the whole of life to live,
> Nor all of death to die.